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ABSTRACT

A constructivistic learning process was used with primary and secondary students in Genoa, Italy, to approach the problem of the diffusion of the alloctonous algae Caulerpa taxifolia in the northwestern Mediterranean Sea. Because of the lack of a continuous research program in Italy, the media played a heavy role in the transfer of information to the public, and an incomplete report by media personnel often caused great confusion in readers. To reach a self-made opinion about the Caulerpa case, students discussed all general information they could find. They observed that the opposite information often reported by the media prevented people from understanding the ecological problem and participating in its solution, but the group declared the scientists "must" know the answers to the problems produced by the exponential diffusion of the species. The learning process supported the disciplinary curriculum of the classes, allowing them to experience the scientific method and to construct knowledge. Discussion of evidence of differences arising from comparison of scientific reprints and the media promoted an awareness learning. Analysis of the concept map prepared by secondary students and the theater script of primary ones verified the positive impact of the process on students' knowledge. Some basic ecological concepts were well understood. (Contains 21 references.) (YLB)

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Crossroads of the New Millennium

Science Education And Controversial Issues:

A Case Study

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Poster Presentation

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Abstract

The media plays a crucial role in the transfer of scientific information on ecological problems to the public. The lack of complete documentation of the reporters often causes confusion in the readers.

A constructivistic learning process has been planned with the students of a primary and secondary schools in Genoa (Italy) to approach the problem of the diffusion of the alloctonous algae *Caulerpa taxifolia* (Vahl) C. Agardh in the north-western Mediterranean Sea. The impact of the introduction of this tropical species is still debated in specialised literature, and supplies a good case-study to the discussion about science education and controversial issues.

To reach a self-made opinion about the "caulerpa case", the students had to discuss initially all the general information they could find. They observed that the opposite information often reported by the media prevented people from understanding the ecological problem and participating in its solution, however, the group declared that the scientists "must" know the answers to the problems produced by the exponential diffusion of the species. More information has been added to the group's discussion, proposing some crucial scientific papers for a critical analysis.

The results of this knowledge process form the self-made opinion of the group and have been transmitted to the scientific community during an international workshop about *C. taxifolia*. A concept map has been constructed to verify the effectiveness of the process. After the discussion of the recommendations from UNESCO about the invasive species of Caulerpa in the Mediterranean Sea, the students concluded that their attention to each fact, altering the natural equilibrium of the Mediterranean Sea, would remain high.

INTRODUCTION

Dealing with science, the media's task must be to present the facts as accurately as possible. In the workshop "Reporting on scientific issues" (BOWMAN, 1998), the Canadian Science Writers' Association stressed that the media personnel handling the environmental problems must be well versed in the topics they report to a heavily relying public. The workshop focused also on the close connection between pertinent information coming from the scientists and intellectually honest and scientifically correct reports from the media writers.

At the end of January 1998 a local Italian newspaper reported the eradication of a colony of *Caulerpa taxifolia* (Vahl) C. Agardh in the Tigullio gulf, East of Genoa (44° 20' N - 9° 13' E) (PLEBE, 1998). At that time, this station was the North-Eastern expansion boundary of the algae in the Mediterranean Sea. In Italian waters, the first specimen of the alloctonous algae had been signalled in 1992 at Imperia (43° 53' N - 8° 01' E) (RELINI & TORCHIA, 1992). In 1996 the extension of *C. taxifolia* had been estimated to concern more than 1300 ha along the Italian coasts of the Mediterranean Sea (MEINESZ *et al.*, 1997); and in 1997 the area affected exceeded 2600 ha (MEINESZ *et al.*, 1998), following an exponential trend of diffusion (MEINSZ *et al.*, 1997).

The news about the presence of *C. taxifolia* in the Tigullio gulf (PLEBE, 1998) was reported to and warned the public of "the presence of the killer algae" and "the assault against it by the experts in coastal management"". The newspaper reported: "Although the scientific community has not yet come to an agreement, the algae is considered quite dangerous by some experts, who stress that it emits toxic substances which poison both fish and man". A few months later, in April, 1998, the same newspaper reported "the killer algae has been rehabilitated: it is not poisonous, it can eliminate the pollution" (TURITTO, 1998) and referred to the "ecological and financial scandal about caulerpa" which a French magazine had initiated (DUBRANA & JUBELIN, 1997). In Italy, owing to the lack of a continuous monitoring programme of the expansion of the algae, the confusion this controversial information produced characterised the public knowledge on the "caulerpa problem".

The international forum consider youth an important recipient of the educational curricula and public awareness programmes on the interaction between human development and the conservation of nature; youth will be the future users or managers of the environment (UNESCO, 1994). In school, the students complete their cultural background, which in the future, will allow them to enjoy and manage the environment. Several reports from the Italian

Ministry of Education suggested promoting environmental education in schools; developing interdisciplinary experiences that could enhance public awareness on environmental protection.

Recent psychological and pedagogical research stressed the transition from the objectivistic (BLOOM, 1956) to the constructivistic conception of knowledge, which is considered socially, historically, temporally, culturally and contextually constructed (DUFFY & JONASSEN, 1992). The practice of assimilating cultural procedures and instruments during experiments shared with contemporaries or adults, proved that it was encouraging a free and autonomous cultural background for students (VYGOTSKIJ, 1978). So the learning becomes a co-operational process which involves the capabilities of different subjects, like pupils, teachers, experts.

The spread of *C. taxifolia* along the coasts of the Mediterranean is a good case study for experiencing scientific education at school levels: this topical subject concerns the sea's environment, which plays a central role in the culture, economy and history of the coastal populations. The concept of danger inferred by the algae in distributed literature and the uncertainty about the consequences of its spread, excite the interest of the pupils. The debate which is dividing the scientific community allows for the enhancement of self-constructed knowledge.

METHODS: PLANNING A LEARNING PROCESS ABOUT A CONTROVERSIAL ISSUE

In scientific education, the planning of a learning process which refers to the constructivistic theory will produce, in students, the awareness of the role of interaction with other subjects and negotiation and mediation in the construction of knowledge (VYGOTSKIJ, 1978). Group discussion is encouraged, with contemporaries and adults (the teacher, the experts); the foreknowledge, coming from former daily interaction with parents, teachers, people and media. The adults themselves will participate with the learning group, sharing their knowledge with students. The hypothesis on the scientific problem risen from the discussion, will be validated by some experiment, designed by the group of learners, to allow the inclusion of the knowledge in the disciplinary frameworks. The influence of the media on the cultural process must be explored to stress the importance of the technological and cultural instruments for mediated knowledge (OLSON, 1979). Misunderstandings and incomplete information are often the results of defective reporting by the media; the correction of the bias they produce in the cultural background of the learners is difficult (VYGOTSKIJ, 1978), but must be attempted to promote conscious behaviour.

The communication of the knowledge attained is a crucial phase of the process, during which the learning subjects re-organise the information to be transferred to (and to be understood by) other people. In this phase, the use of different languages points out the interdisciplinary nature of the culture and stresses that it is distributed by interpersonal exchanges (OLSON, 1979).

Several methods have been proposed to verify the effectiveness of the learning process. Between them, the concept maps (NOVAK & GOWIN, 1984) combine the control of the educational process with the evidence of the significance of the knowledge, forcing each component of the learning community (students, teachers and experts) to reflect upon the contents and the structure of his own culture. The map points out the hierarchical connections between the concepts composing the knowledge.

Controversial issues are very useful in the planning of a learning process. They force the subject to approach a problem without pre-conceptions, following a flexible pattern of reasoning. The working hypothesis, proposed by the learner, is evaluated by a reflective practice; to promote a free approach to the environmental problems. This encourages the capability of the students to solve new problems and to face new situations (TOBIN, 1993).

The project we discuss involved a class of the "Scuola Media Statale C. Durazzo" (a secondary school in Genoa; students age: 11-14 years) during the years 1996-1998 and a class of the "Scuola elementare statale N. Fabrizi" (a primary school; students age: 8-9 years) during the year 1995-1997. The interest in the spread of *C. taxifolia* in the Ligurian Sea lead the students of both schools to collect bibliographical information produced by the media (newspapers, magazines and television). Great confusion arose from reading varying reports on the same subject, so the learning groups sought marine biology and didactic experts to obtain the "true information" about the ecological problem. A learning process was planned to perform the construction of an autonomous and free understanding of the facts by the students. The constructivistic theory was the reference background for the project. In the first phase, the plan forecasted: a) the collection of information from the media; b) its group discussion both with contemporaries and with adults; c) the proposal of working hypothesis; d) their experimental validation; e) the transfer of the acquired knowledge to the public by some kind of report (PILO & DE PAZ, 1999). The students of the secondary school arranged the information collected from the media by producing a report, while the primary level pupils produced a theatre performance. The analysis of both the documents did not solve the doubts the youth had on the impact of the algae in the Mediterranean Sea. To supply less biased and more detailed information, in the second phase of the project, we proposed analysing some scientific reprints

dealing with the caulerpa problem to the groups (DOUMENGE, 1995; GIACCONE & DI MARTINO, 1995; MEINESZ & HESSE, 1991; RIGGIO, 1995, SANDULLI et al., 1995; VERLAQUE, 1994). The reprints have been chosen as representative of two different scientific evaluations of the caulerpa problem; the first (Doumenge, Giaccone, Riggio) considers the expansion of the algae in the Mediterranean Sea as the consequence of the lessepsian migrations through the Suez Channel and the survival of the seaweed populations of Thetis in the Eastern basin. The second (Meinesz, Verlaque, Sandulli) pays attention to the ecological impact of the exponential expansion of the algae, stressing the need for a control method which could allow the reduction of the damage caused on the original sea community.

The disagreement existing in the scientific community (reflected in the number of reprints supplied to the students) gave rise to the process of the construction of the groups' own opinion. The visits to the Aquarium of Genoa, in which *C. taxifolia* is exhibited, and to the seashore supported this phase of the project. A concept map about *C. taxifolia* (Fig.1) has been drawn by the secondary level class, ranking in a descending inclusive order the concepts arising from the knowledge of the students and linking them in simple sentences. In the final phase of the project, the UNESCO "Heraklion conclusions and recommendations" (MEINESZ *et al.*, 1998) supplied to the secondary level learning group the present discussion about caulerpa, showing the effort of several nations facing the Mediterranean Sea dealing with the problem starting from a shared knowledge and with common aims.

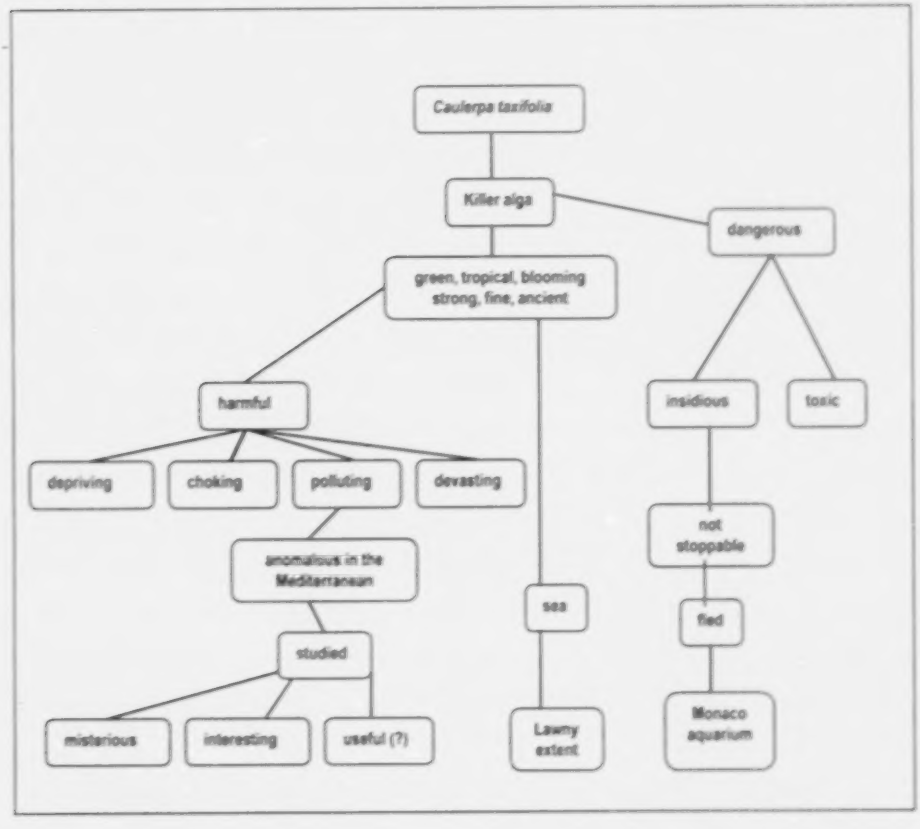

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Fig. 1: concept map of knowledge on *C. taxifolia*.
Students of the secondary level class.

RESULTS OF THE LEARNING PROCESS

In a science education experiment, the main results can be recognised in the cultural background of the learning group. Constructivism states that the learning subject builds himself up with knowledge; so the central aim of the process we present is the construction of a self made opinion on the controversial problem discussed. In the following paragraphs (*in italic style*), we present the contents of the report wrote by the secondary level students or of the theatre script from the primary ones, to allow the reader to experience their learning process. Describing the first phase of the work, the secondary level pupils wrote:

> *We started collecting information by reading articles in magazines and newspapers, but we soon realised that they did not agree with one another. We thought that a biologist could tell us how things really stood; instead, he suggested that we should read some scientific reprints* (see above) *written by other scientists, discuss the problems with him and try to make our own conclusions. It was exciting to enter the world of science. We discovered that there is a minority of scientists who say that the spreading of caulerpa is dangerous for the Mediterranean. We did not imagine that the researchers were still discussing the causes and effects of the problem, without finding a common agreement. It was difficult to build up our own idea about the presence of the killer algae in our sea: it is easy to be misled by what one reads. It is difficult to be well informed. We discovered that where caulerpa is present, the other species disappeared. We read that it does not seem toxic for all marine organisms, and we decided that it would be better to increase our research about its toxicity. We were surprised at its speed in spreading on the sea bottom; the biologist showed us the various methods used (without success) to stop it. Some of us suggested waiting for some years to see what would happen, but we have noticed that it keeps on spreading along the coast. We also asked ourselves if it would be as dangerous in surroundings with no life forms, as in a port, but some of us said that from the port it could spread into other surroundings. To better understand this algaeand its method of occupying the marine bottom, we did some field research on the beach and visited the Aquarium of Genoa, where C. taxifolia is kept."*

On the other hand, the script of the primary level pupils is the result of a former knowledge experiment on the marine communities of the north-western Mediterranean Sea. During that

experiment, the sea grass meadows attracted the curiosity of the students, who knew from the media that the so called "killer algae" was threatening the underwater prairies. So, the script tells about the disturbing appearance of *C. taxifolia* in the stillness of a sea grass meadow. The youth imagine the algae as a cunning and fighting species that wish to become *"the queen of the sea"*. The terrible battle stops at sunset, and during the night the few surviving species of the meadows call for the old octopus' help. In the fantasy world of children, only magic will solve the ecological problem: the controversial information collected from the media didn't supply them sufficient knowledge to propose a more scientific solution. But their curiosity was not satisfied; so we proposed to them a summary of the scientific information contained in the above mentioned reprints of DOUMENGE (1995), GIACCONE & DI MARTINO (1995), MEINESZ & HESSE (1991), RIGGIO (1995), SANDULLI *et al.* (1995) and VERLAQUE (1994). After critical discussions, the pupils proposed some corrections to the conclusion of the theatre script: resuming the opinion that caulerpa is a species capable of remedying a polluted environment; someone proposed a final round table between the marine species, discussing the integration of the algae in the local community. Another, observing the competitiveness of the algae and its toxicity to some marine species, proposed a drastic scenario in which all the marine species are replaced by caulerpa. The pupils suggested that the new prairie could generate a new habitat, supporting the presence of the species which formerly disappeared due to the pollution.

Also the secondary students presented their opinion on the caulerpa case:

> *"This year, after the biologist brought us up to date on the spreading of C. taxifolia and the research on the algae, we tried to draw our own conclusions.*
> *For us the caulerpa problem is not one to be ignored: it is still difficult to know if the spreading of the algae will stop; the researchers themselves aren't in agreement and the methods used till now to fight it have proved almost useless. We agree that its presence causes the disappearance and suffocation of many species (both animals and plants) on the sea bottom, damaging the environment. Fortunately, it is not toxic for man and for many species that live in the sea. Even though it seems clear that it has been introduced in the seawaters in front of the Monaco Aquarium, some of us think that it is wrong to try to find who is responsible for its presence. We have understood that it is an algae that has been modified by man to embellish some artificial environments, such as fishponds, and these alterations have become a problem when caulerpa has entered the natural environment. We were sorry to learn that in Italy it is still possible to buy C. taxifolia in shops which sell equipment*

for aquarium: some bits of the algae could have been dropped somewhere into the sea, speeding up the spreading of the algae along our coastline.

The discussion preceding the draft of this final part of the secondary students' report allowed us to construct the concept map of the knowledge of the pupils. The map summarises the results of the learning process carried out by the group, allowing it to estimate the effectiveness of the project and its impact. In the map (Fig. 1), "killer algae" is the most inclusive concept connected with *C. taxifolia*, showing the deep impact of the media message to the inexperienced public. This concept is more important than "green algae" or "polluting" element; the "pollution" concept is included in the harmfulness, which, in the culture of the students, is a typical feature of this "blooming" algae. The pollution concept includes the "anomalous" presence of the seaweed in the Mediterranean and the interest for research on its spread; a member of the group proposed the study of its possible usefulness for future research. The "danger" of the "unstoppable" expansion of caulerpa and its "toxicity" is a more inclusive concept, directly connected with the "killer" nickname of the alga. Its "unstoppable" expansion and "toxicity" are considered by some members of the group, to be more important than the identity of the entity which discharged it into the Mediterranean.

CONCLUSIONS

The essential problem of scientific education is not only to improve the understanding of disciplinary concepts and to prepare new scientists and technicians, but also to foster in the public the ability to screen the information from the media and to participate consciously in the decisions on the use of environmental resources and the results of scientific and technological knowledge.

In Italy, because of the lack of a continuous research programme, the media played a heavy role in the transfer of information to the public; an incomplete report by media personnel often caused great confusion in readers. So, the sensitisation of the large public about the spread of *C. taxifolia* becomes one of the crucial purposes of the projects monitoring this ecological problem.

The learning process we proposed to the students supported the disciplinary curriculum of the classes, allowing them to experience the scientific method and to construct knowledge, which was significant for the learners themselves. The discussion on the evidence of the differences arising from the comparison between the scientific reprints and the media, promoted an awareness learning in both groups.

The analysis of the concept map of the final report, prepared by the secondary students and of the corrected theatre script of the primary ones allowed us to verify the positive impact of the process on the knowledge of the students. Some basic ecological concepts have been deeply understood: pollution implies that an anomaly happens in the system, and is directly linked with the concept of harm. The danger for the expansion of *C. taxifolia* along the Mediterranean coasts implies difficulty in its control. The nickname "killer algae" is related to the seaweed as a linguistic definition; its meaning is connected more with the disappearance of other marine species in the affected areas than with its toxicity. During construction of the map, both the teachers and experts involved in the project had to organise their knowledge, before imparting it to the group.

Any further considerations about the project can be well summarised by the conclusions drawn by the students themselves; one of the opinions of the primary pupils is:

> *"If we can detect that caulerpa chokes the sea grass, we should find some method to eliminate it. It is necessary, however, to take care and to understand whether the killer of the sea grass is the algae or man polluting the sea. Every one of us can offer some money to allow the scientists to do more research on the algae and its dangers."*

The secondary group reports:

> *"We were very interested in this problem because we love nature and we do not like to upset the balance of an environment so rich, fascinating and singular as the Mediterranean Sea. We will always endeavour to respect it and pass on our feelings to future generations."*

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